FAA Questions and Comments Through ARAC Ex-Com on the June 2001 FTIHWG Final Report

<u>Question No. 1</u>

During the August 8, 2001, presentation to the ARAC Executive Committee, the FTIHWG Co-Chairs described the results of a recently completed Sensitivity Study that was based on varying the assumptions in the report's cost-benefit study. The specific inputs that were varied, the amount they were varied, and the results of the sensitivity study should be included in the text of the report - perhaps a table listing all of these would help to simplify and clarify the analysis. Further, any changes requested by Executive Committee members should also be included. It is suggested that these be placed in the Executive Summary as Section 1.2.

Response:

The Working Group agreed the entire document will not be reprinted with the changes because of the time and cost involved. The Ex-Com comments and the sensitivity analysis will be included in an addendum to the Executive Summary and limited changes will be made to the Executive Summary text.

<u>Question No. 2</u>

The Executive Summary states the FTIHWG did not recommend any new regulatory text. Recommending regulatory text was part of the tasking statement. When asked about this during the August 8 Executive Committee meeting, one of the FTIHWG co-chairs stated there are recommendations in the text of the report for the FAA to consider if FAA should propose fuel tank flammability regulations based on fuel tank inerting. The Executive Summary should be revised to inform the reader where those recommendations can be found in the report.

Response:

The following text will be included here, as part of the addendum to the executive summary:
"The FAA Tasking Statement for this ARAC FTIHWG study required that this Working Group "prepare a report to the FAA that provides recommended regulatory text for new rulemaking and the data needed for the FAA to evaluate the options for implementing new regulations that would require eliminating or significantly reducing the development of flammable vapors in fuel tanks on in-service, new production, and new type design transport category airplanes. Although the Working Group did not recommend new rulemaking, the Working Group did conduct an evaluation of existing regulations, advisory material and continued airworthiness instructions concerning the elimination or reduction of the flammable environment in the airplane using a nitrogen inerting system. The Working Group found that 14 CFR Part 25 and

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14 CFR Parts 91, 121, 125, 129 and 139 would be significantly impacted by the introduction of a fuel tank inerting system and that the 14 CFR changes were linked to the inerting system concept. For this reason, the Working Group recommended that a dedicated paragraph, "Fuel Tank Inerting System" / "Operation of Fuel Tank Inerting System", be incorporated in each effected 14 CFR part and that associated guidance material should be developed. The Working Group then developed preliminary regulatory and guidance material proposals, as requested by the FAA. The Working Group recommended that these proposals be refined if and when a practicable inerting system is developed and integrated on a certified aircraft. Specific details concerning regulatory and guidance material development is found in Section 12.0."

Question No. 3

The tasking statement required the Fuel Tank Inerting Harmonization Working Group "prepare a report to the FAA that provides recommended regulatory text for new rulemaking and the data needed for the FAA to evaluate the options for implementing new regulations that would require eliminating or significantly reducing the development of flammable vapors in fuel tanks on in-service, new production, and new type design transport category airplanes." The report discusses the results of the cost-benefit study performed by the FTIHWG, but it does not contain all the data required under the task. Although the appendices to the report, the Team Reports, include aggregate cost estimates and much of the supporting data, they do not provide all of the data used to support those aggregate estimates. Specifically, there is no explanation of the basis for the estimated engineering hours for the certification costs, no description of the components and their individual costs for the major supplier parts and the major assemblies cost categories, and the costs involved in the service bulletin and parts kit estimates are not adequately explained. Assumptions used as the basis for each of the economic assessments in the document should be summarized at the front of each section, so the FAA and the public can easily understand the basis for the assessment.

Response:
Because of time and resource constraints the Working Group was not able to amend each section of the final report with the cost assumptions.

The certification detailed cost breakdown and the associated assumptions are found in Appendix I. The supplier part and major assembly costs are listed in Appendix D, (On-Board Design). The airport costs are included in Appendix E and the airline operation, maintenance and installation costs are included Appendix F. To develop a more detailed cost assessment, the Working Group recommends that the FAA work with airplane and equipment manufacturers to evaluate the costs on specific airplane models.

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Question No. 4

The estimated costs appear to include service bulletin and parts kits costs for airplanes modified during production (new production airplanes) as well as retrofit of in-service airplanes. Why would each individual (future) new production airplane require a service bulletin and a kit of parts? Why would the parts cost be at the same level as the costs for a retrofit of an in-service airplane? The Sensitivity Analysis should reduce the installation costs from that used in the report based on this issue.

Response:

It is assumed that the writer's question addresses the standard format used in Figures G9-G63. The FTIHWG agrees that a Service Bulletin would not be issued for in-production or future production airplanes. However, the costs associated with activities such as certification, engineering drawings, records and technical publications, warranty and customer support, parts receiving and inspection, inventory planning, tooling, materials and supplier parts costs are required for either a production change or a Service Bulletin. For a production installation, it was assumed that the cost savings from not drafting a Service Bulletin is offset by the additional costs of the manufacturing planning, production illustrations and engineering support to the shop, system checks and inspections required for a production incorporation. It was also assumed that the component and material costs were the same for the new, production and in-service generic category airplanes. This assumption simplified the economic calculations. The FTIHWG does not believe it is valid to reduce the Sensitivity Analysis based on these factors mentioned in this question.

Question No. 5

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The Economic and Forecasting team used a spreadsheet to calculate the estimated costs of the inerting systems provided in the report. This spreadsheet needs to part of the report so it is available to both the FAA and the public.

Response

A public version of the spreadsheet will be given to the FAA to include with the final report. The spreadsheet allows the user to vary cost and benefit values, fleet sizes, and other parameters and compare the results against the baseline values.

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Question No. 6

The report states neither the bleed air nor the electrical energy available on in-service airplane designs is adequate to power an on-board fuel tank inerting system. The lack of available bleed air led to the requirement for an air compressor on all on-board designs. However, there are no data in the report to support this conclusion. For bleed air, supporting data should include bleed air available from the engines and bleed air requirements. For electrical energy available, supporting data should include consideration of load shedding priorities. For both bleed air and electrical energy, supporting data should show during which flight and ground conditions the availability is limited.

Response:

The Working Group's conclusion that in-service and current production airplanes lack the bleed and electrical power to meet the demands of on on-board inerting system was based solely on statements made by representatives of airframe manufactures and operators during the Working Group discussions. No data was presented to the Working Group to support these conclusions. The study evaluated six generic airplane sizes. Engine bleed and electrical power is airplane specific information. Airplanes are designed and certificated to supply the required bleed and electrical power under normal and certain failure conditions. On some airplanes, combinations of these conditions, such as engine idle, hot day temperatures or engine-out operation require all of the available engine bleed or electrical power. The Working Group assumed that additional bleed and electrical power demands could degrade functions such as anti-icing capability, cabin pressure or temperature control or air-driven pump performance. The actual effects of additional bleed and power extraction required to supply on-board fuel tank inerting systems should be evaluated further by the FAA on an airplane model-by-model basis.

Question No. 7

The FAA has been evaluating a fuel tank inerting/cargo compartment fire suppression system based on a single on-board nitrogen generating system. This was discussed during the FTIHWG team meetings and also several at public research and development meetings that included representatives of the aerospace industry. Evaluation of this combined system was not part of the tasking statement and the on-board task team chose not to voluntarily evaluate it as part of the work performed in this study. However, such a system would eliminate a significant amount of weight from existing airplanes by removing the existing (long duration) Halon based cargo compartment fire suppression system used to keep cargo compartment fires from re-igniting after a cargo compartment fire has been put out by another Halon "knock-down" system. What would the affect be on a new airplane design if the weight of such an inerting system were offset by not requiring the installation of a long duration Halon cargo compartment fire suppression system? The Sensitivity Analysis should reduce the installation costs from that used in the report based on this issue.

Response:

Although a single fuel tank inerting/cargo compartment fire suppression system was discussed conceptually, no information, design, analytical, application or test data was presented to the FTIHWG on such a system. The FTHWG did not have the time or resources to combine the two system designs and conduct trades studies to optimize the system design. Also, the fuel tank inerting sensitivity analysis spreadsheet lacks the data to perform a combined system cost calculation. The Working Group believes that in a new airplane design, it is possible some synergy of design may be achieved by incorporating a combined system. The FAA should further study this concept.

Question No. 8

The fuel tank volume used for the generic large transport airplane, which is the basis for the cost study of inerting large transports, is larger than the actual fuel tank volume of most in-service large transport airplanes. This results in a higher cost estimate for inerting large transport airplanes than would be calculated if the actual mix of in-service fuel tank volumes were used in the cost study. Appendix D of the report does provides parametric sizing curves to determine equipment requirements based on selecting a fuel tank size and airplane turnaround time which will enable determining equipment sizes for actual in-service tank. However, the Executive Summary of the report should acknowledge this limitation on the cost data presented in the report.

Response:

The question makes a point that the generalized aircraft used in the study could overstate the large fuel tank volumes thus overstating the costs of providing nitrogen for inerting this class of airplane. The Team acknowledges that the use of generic airplanes will overstate or understate the costs and benefits of airplanes within each of the six generic categories. The working group agreed to use the same generic airplanes categories that were used by the 1998 ARAC fuel tank study. Errors from using the generic airplanes are small and tend to compensate each other. This information will be included in the revised Executive Summary.

Question No. 9

Section 1.9 of the FTIHWG report estimates that 24 to 81 lives may be lost as a result of nitrogen inerting of fuel tanks over the 2005 - 2020 study period. The text implies these lives would be lost as a result of exposure to inert (oxygen depleted) atmosphere inside fuel tanks during

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fuel tank system maintenance. Occupational Safety and Health Administration (OSHA) requirements and fuel service industry practices for preparing fuel tanks for maintenance require ventilating the tank with air until the oxygen level is above a minimum limit value and the hydrocarbon concentration is well below the lower explosive limit. In addition maintenance personnel are already required to wear oxygen and hydrocarbon concentration detectors with alarms when entering fuel tanks. Therefore, the statements in the report about increased deaths as a result of fuel tank inerting should be removed from the Executive Summary and the costs for additional confined space training and safety equipment should not be included in the report or the Sensitivity Analysis.

Response:

The FTIHWG reached general consensus that that it should acknowledge the hazards associated with nitrogen inerting systems and the need for further study in the Executive Summary. As stated in the first sentence of paragraph 2 of Section 1.9, "The FTIHWG lacks the expertise to assess these risks with confidence". However, the available historical data does suggest that, despite the best intentions, procedures and regulations, accidental fatalities do happen. As already indicated, since the FTIHWG do not consider themselves sufficiently expert to evaluate the impact, and the cost associated with these estimated fatalities were not included in any of the statistics used to generate the study costs or the costs in the Sensitivity Analysis. The costs for additional training and equipment were listed in Appendix F but were not included in the cost estimates or sensitivity analysis.

Question No. 10

Appendix G, page G-1, states the airplane weight penalty costs are based on the 1998 (FTHWG) ARAC study. The cost factor driving these estimates are estimates of the number of flights that would face distance and weight limitations because these earlier systems were much heavier than the systems described in the 2001 FTIHWG report. Those estimated losses were, in turn, built into the fuel cost estimate. A more appropriate value for the lower weights of the inerting design concepts presented in the 2001 FTIHWG report was to be used in the Sensitivity Analysis. This lower weight penalty cost should be part of the documentation of the Sensitivity Analysis. The table below compares the weight penalty used in the report and the Sensitivity Analysis.

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Generic Airplane Size	$ Per 1,000 lb.	Sensitivity Analysis
Large (Generic) Transport	$165,532	25.5 gal/lb.
Medium (Generic) Transport	$131,802	26.5 gal/lb.
Small (Generic) Transport	$62,004	7.4 gal/lb.

Response:

The question addresses weight penalties in the sensitivity analyses. It will be included here as part of the addendum to the Executive Summary.

Question No. 11

The report estimates the airplane turnaround time for each generic airplane category. Appendix F (page F-27) of the report then bases the mean time between failure (MTBF) calculations using a much longer turnaround. This creates an unrealistically high rate of failures and generates high estimated maintenance cost. The Sensitivity Analysis should use MTBF calculations based on the same turnaround times used in the equipment sizing analysis.

Response:

This question pertains to the on-board ground system sizing and usage. The minimum turn times used in the study were determined using actual operating data obtained from the operators. Operators all have a minimum amount of time required to turn an aircraft between flights for each aircraft type in their operation. This "minimum" turn time is used in developing their operations flight schedules. Some operators regularly schedule their flights using minimum turn times. Others simply use the "minimum" turn time as a benchmark to make sure that sufficient time is included in their schedules to turn the aircraft. Early in this study the Working Group concluded that the inerting process must not increase the aircraft turn times because of significant impact on airport infrastructure and airline operations. As a result, the minimum turn times for each aircraft category were determined and used as a design parameter in system sizing to ensure that the inerting system could inert the fuel tanks within the minimum turn time.

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However, not all flights are turned in the minimum turn times. It was assumed that the on-board ground system would operate during the time the airplane was at the gate. To accurately determine the system reliability the average operating time was used based on an average turn time. To estimate the operating time for a system based on the minimum turn time which was a lower limit design parameter would severely underestimate the average system operating time and therefore the operating costs. However, an automatic shut-off feature could be added to the control system of the on-board ground systems to minimize their running time.

In addition, this question assumes that operating time is the only factor effecting the MTBUR and MTBF of a component. In fact depending on the type of component operating cycles and exposure to environmental factors can have a larger influence on component MTBF. It is true that operating time is a significant factor in the MTBF for a motor or compressor. But it is also true that operating cycles and exposure to environmental factors have a much larger effect on components such as valves, seals, ducting, wiring etc. Because turn time is not a factor on the full OBIGGS systems we have looked at the sensitivity of the reliability data for the GBI and OBGI systems. The OBGI system has three components that would be significantly effected by decreasing the operating time. Those components would be the compressor, the cooling fan, and the air separation module. Decreasing the operating time for these components by 50% would double their MTBF. However, it would only increase the System MTBF by ~9%, from 960 hrs to 1038 hrs. A similar benefit would be realized in the corresponding System Annual Failure rates and Unscheduled Labor Hours to maintain the systems. The reliability of all of the components in the Ground Based Inerting system are primarily effected by component cycles not operating time and therefore changing the operating time would have little or no effect on system MTBF.

Question No. 12

The cost estimate is based on modification of a portion of the in-service fleet performed during scheduled heavy ('D') checks and another portion of the fleet modified by taking the airplanes out of service dedicated for "non-scheduled" modification. The report should justify the need for modifications outside the scheduled heavy check time period. The Sensitivity Analysis should reduce the installation costs from that used in the report based on this issue.

Response:

After evaluating the scope of the modifications, the Maintenance and Operations team concluded that, most operators would not be able to schedule incorporation of the inerting systems during an airplane's regular heavy maintenance visit. Because it is very expensive to have aircraft out of service for any amount of time, airlines put a lot of effort into carefully planning the work package. The goal is to maximize the efficiency of the work package and use of the facilities thereby minimizing the time out of service. In part, this means utilizing enough technicians to accomplish the most concurrent work possible without having one task interfere with another. An evaluation of the modification

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work package by the Maintenance & Operations Task Team determined that incorporation of the modification into a heavy check work package would result in a significant extension to the length of the check. The amount of time between aircraft heavy checks is driven by calendar days and flying time. Once the aircraft runs out of time it must be taken out of service until the heavy check can be accomplished. Most operators' heavy check facilities are tightly scheduled and a significant increase in the length of the check would force the operator to contract out heavy checks or ground the aircraft. With the scope of this modification, it is likely that many operators would opt to avoid disrupting the efficiency of the heavy check line by accomplishing the modification in dedicated modification lines or by contracting the modifications out to other maintenance facilities. This eliminates the risk of grounding multiple aircraft by backing up a "heavy check" maintenance facility line.

Question No. 13

When modified during a scheduled heavy check, the report states the airline will be required to extend the time for the inerting modification by 7 to 9 additional days even for a ground based inerting manifold installation. The reason given is the airline can not perform other maintenance on the airplane when modifying the fuel tank. A more detailed justification for this reason should be provided. A large portion of the installation is work performed outside the tank. Also, work can be performed on the aircraft during fuel tank modifications provided it is done in accordance with the lockout, tag-out procedures in place. The Sensitivity Analysis should reduce the installation costs from that used in the report based on this issue.

Response:

As discussed earlier, it is very expensive to have aircraft out of service for any amount of time, therefore airlines typically put a lot of effort into carefully planning the check work package. The goal is to maximize the efficiency of the work package and use of the facilities thereby minimizing the time out of service. In part, this means utilizing enough technicians to accomplish the most concurrent work possible without having one task interfere with another. The work package labor estimates included in Appendix F-A1 & F-A2 were developed by experienced aircraft maintenance program planners with the goal of maximizing work flow to minimize the aircraft out of service time. Many considerations were taken into account including access requirements for all concurrent tasks, electrical power requirements, safety regulations, etc. Wherever possible, modification tasks would be scheduled concurrently with other work. However, in many cases space and resource requirements for one task will interfere with another task in the same area and therefore they cannot be accomplished concurrently.

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Question No. 14

The FTIHWG should evaluate using a simplified inert gas distribution manifold with ports in only two or three bays. This concept has been shown on recent scale model testing at the FAA Technical Center to inert the fuel tank even more efficiently (less nitrogen required) than the more complicated manifold design used in the report. The Sensitivity Analysis should reduce the installation costs from that used in the report based on this issue.

Response:

Since the scale model test results were not available to the HWG at the time their evaluations were completed regarding inerting systems, it was not possible to include these scale model tests manifold system. In addition, none of the HWG participants have any knowledge of the test results or their relevance and therefore cannot estimate its impact in the Sensitivity Analysis. The HWG believes once the full-scale testing and analysis results are available for use, the applicability and/or impact on the Sensitivity Analysis should be studied at that time.

Question No. 15

The ground based inerting section of the report does not provide a need for installing any indication or activation system in the cockpit; however, the cost for installation of the ground based inerting system includes installation of cockpit instrumentation. The costs associated with installing cockpit instrumentation or activation should be eliminated to further streamline the installation and maintenance costs. This would reduce the installation time significantly from the over 1000 hours stated in the report. The Sensitivity Analysis should reduce the installation and parts costs from that used in the report based a system with no cockpit indication of activation system.

Response:

The parts cost did not include a flight deck indication system. The installation costs could be reduced by 43 hours per airplane.

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Question No. 16

Does the estimated cost to incorporate inerting on new production airplanes include a reduction in labor installation time as more and more of these systems are installed on airplanes after the first one (learning curve improvements)? The Sensitivity Analysis should reduce the installation costs from that used in the report based on learning curve improvements.

Response:

It was recognized that the initial inerting system installations would require more labor hours. The estimate for production incorporation represents a mature installation value. This mature value gives a good average over the production life of the airplane.

Question No. 17

The report states that some airports have placed restrictions on running APUs, but the report does not provide substantiation of this statement. This resulted in the requirement to include an air compressor in the on-board inerting designs. The report should substantiate this statement and list the airports that restrict the operation of APUs. The list should identify which are U.S. airports and non-U.S. airports.

Response:

An air compressor was chosen because bleed air was not available during the phases of flight when inert gas was needed to supply the fuel tanks. The reasons are described in the Onboard Design Team report (Appendix D) where each of the systems is described. APU noise restrictions were discussed but this was not the primary reason for including an air compressor in the design.

Question No. 18

The report does not identify separate costs to implement fuel tank inerting concepts on in-service, new production and new airplane designs. Include costs for each category of airplane in the Executive Summary for both the basic report and the Sensitivity Analysis.

Response:

The cost summary charts in the report combine the costs and benefits for in-service, production and new airplane designs. As an example, two scenarios are included below to show the results for separate categories airplanes. Figures 1-3 show the costs and benefits for scenario 7.

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Figure 1 is the combined cost of new and existing airplanes. Figure 2 is the combined retrofit cost of the fleet only. Figure 3 is the combined cost of new airplanes only. Figure 4 is the combined cost of new and existing airplanes. Figure 5 is the combined cost for retrofit of the existing fleet only. Figure 6 is the combined cost of new airplanes only.

Question No. 19

The SFAR requires development of design changes to correct any design deficiencies identified by the analysis. These changes may be mandated into the existing fleet through the normal airworthiness directive rulemaking process. In the Sensitivity Analysis, what would be the affect on the estimated benefit of fuel tank inerting if inerting were required to be implemented before implementation of any modifications that may result from the design reviews required by SFAR 88?

Response:

The analysis required to answer the above question would require significant additional resources, time and effort by the FTIHWG. These resources are not available to the FTIHWG and consequently the additional evaluation cannot be accomplished.

Question No. 20

The analysis does not include any benefit for preventing future accidents that could be caused by sabotage, such as a small bomb. The National Transportation Safety Board (NTSB) recommended the FAA consider developing airplane modifications such as fuel tank inerting (safety recommendation A-96-174) in a letter to the FAA dated December 13, 1996. In that letter, the NTSB cited a November 17, 1989, Avianca Flight 203 airplane crash as being caused by small bomb that could be prevented by fuel tank inerting. As stated in the letter, a small bomb was placed under a passenger seat above a center wing tank (CWT). The letter states "the bomb explosion did not compromise the structural integrity of the airplane; however, the explosion punctured the CWT and ignited the fuel-air vapors in the ullage, resulting in the destruction of the airplane." The Sensitivity Analysis should include calculated benefits of inerting based on including prevention the accident referenced above in the service history analysis.

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Response:

The FTIHWG acknowledges that inerting may offer some benefit in preventing fuel tank explosions caused by small explosive devices that would not otherwise result in a catastrophe. However, those benefits could not be quantified because of uncertainties related to secondary ignition sources and the loss of nitrogen following breach of the fuel tank. If the FAA and/or NTSB has information that resolves the uncertainties discussed above, the FAA has the option to include that accident in their regulatory evaluation process.

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Figure 1

Scenario 7 - Hybrid OBIGGS, HCWT only, Large and Medium Transports, Membrane Systems, & Small Transports, PSA/Membrane Systems

New & Existing A/P

US-Operator

Study period from Rule effect
4th Quarter 2004 thru 2020

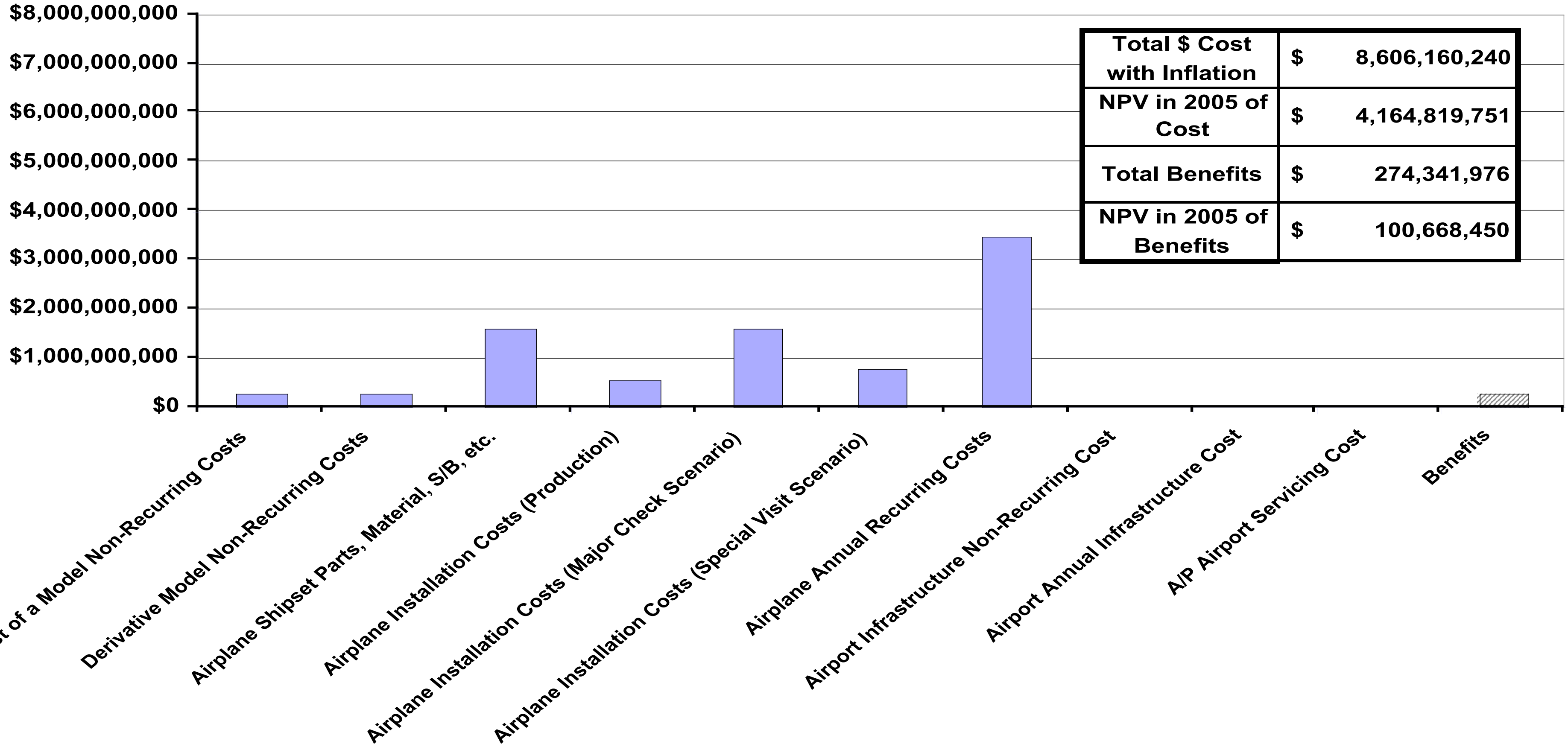

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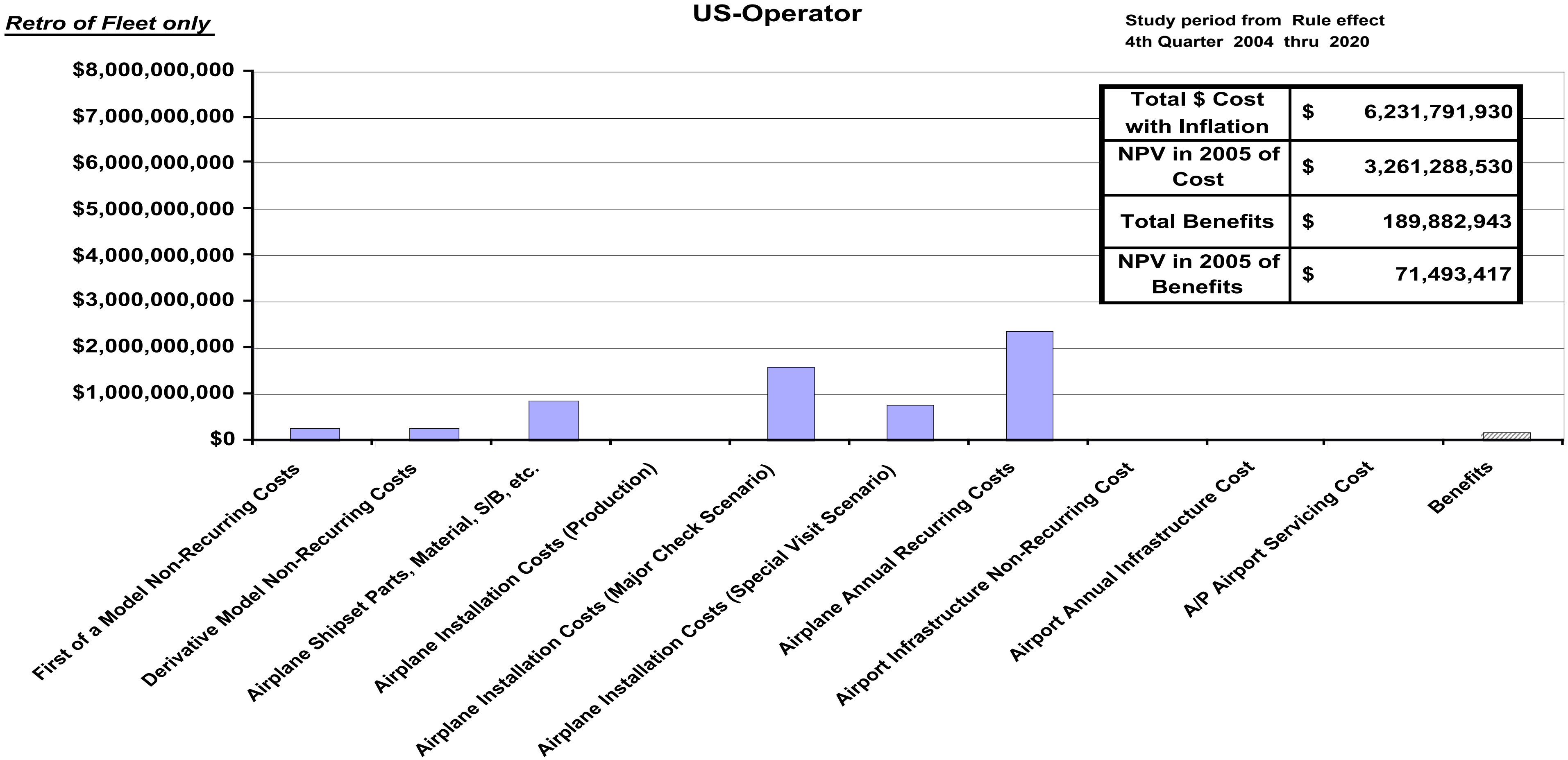
Figure 2

Scenario 7 - Hybrid OBIGGS, HCWT only, Large and Medium Transports, Membrane Systems, & Small Transports, PSA/Membrane Systems



Total $ Cost with Inflation	$	6,231,791,930
NPV in 2005 of Cost	$	3,261,288,530
Total Benefits	$	189,882,943
NPV in 2005 of Benefits	$	71,493,417

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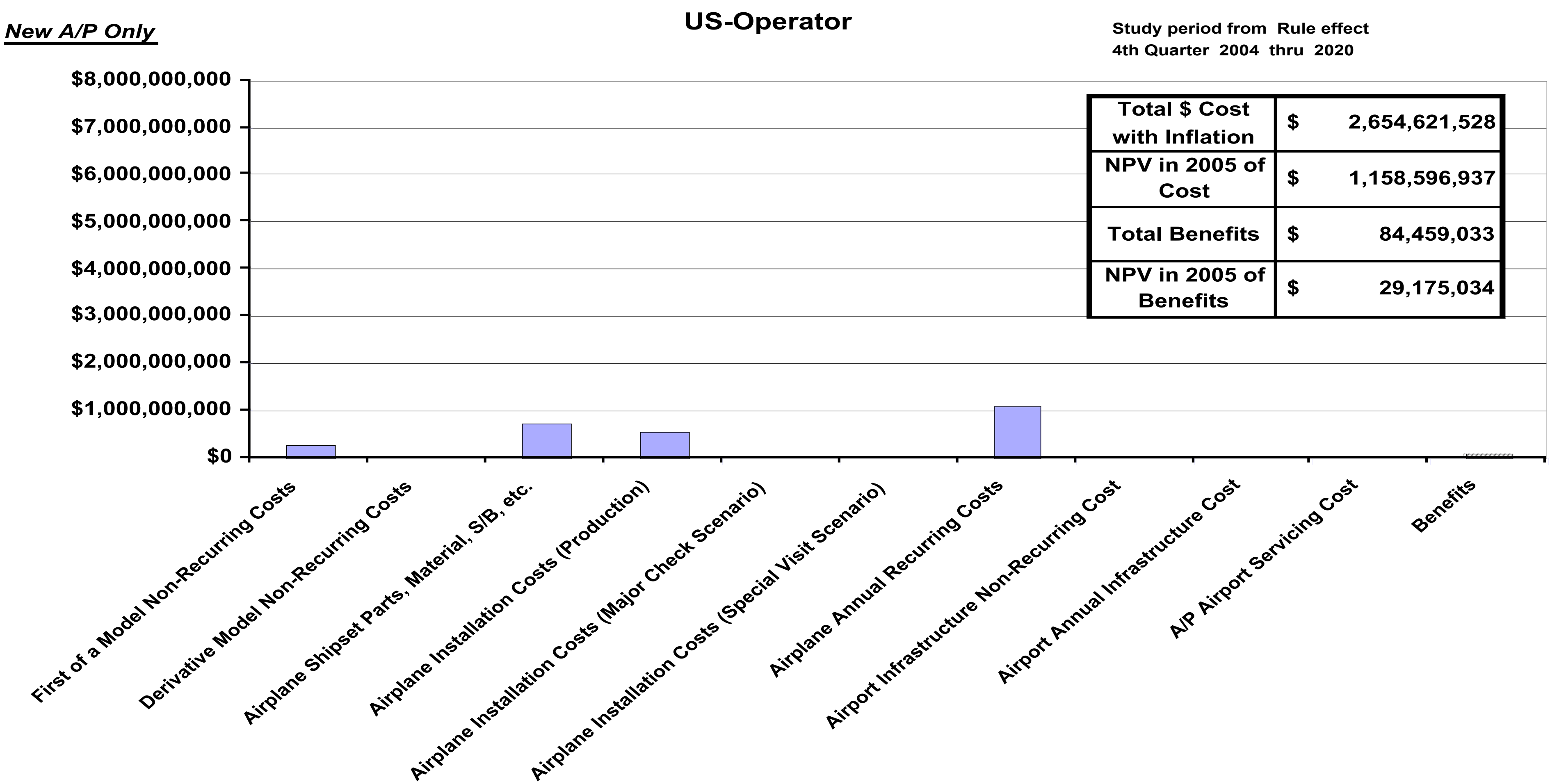
Figure 3

Scenario 7 - Hybrid OBIGGS, HCWT only, Large and Medium Transports, Membrane Systems, & Small Transports, PSA/Membrane Systems



Total $ Cost with Inflation	$	2,654,621,528
NPV in 2005 of Cost	$	1,158,596,937
Total Benefits	$	84,459,033
NPV in 2005 of Benefits	$	29,175,034

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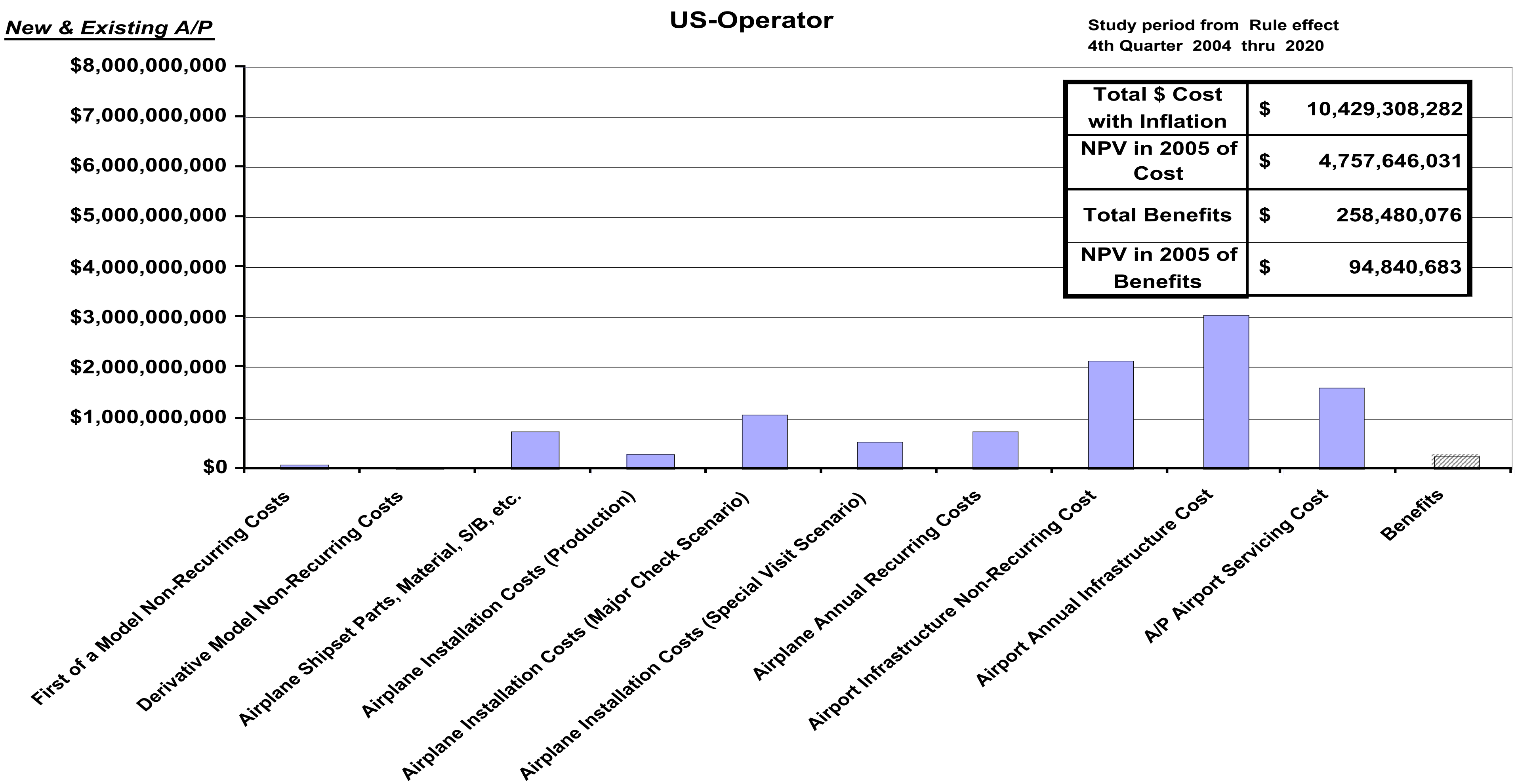
Figure 4

Scenario 11 - Ground Based Inerting HCWT only, All Transports



Total $ Cost with Inflation	$ 10,429,308,282
NPV in 2005 of Cost	$ 4,757,646,031
Total Benefits	$ 258,480,076
NPV in 2005 of Benefits	$ 94,840,683

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Figure 5

Scenario 11 - Ground Based Inerting HCWT only, All Transports

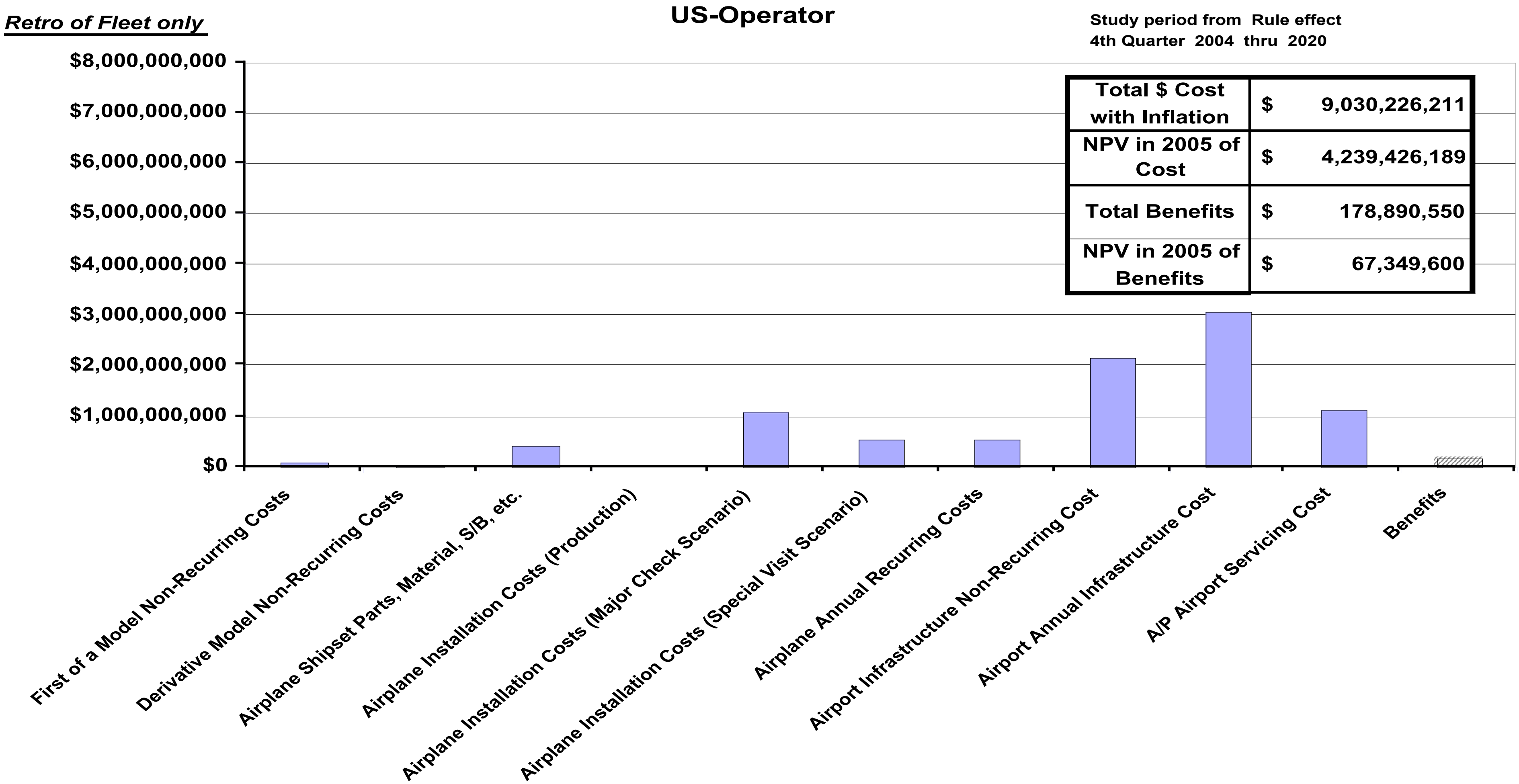

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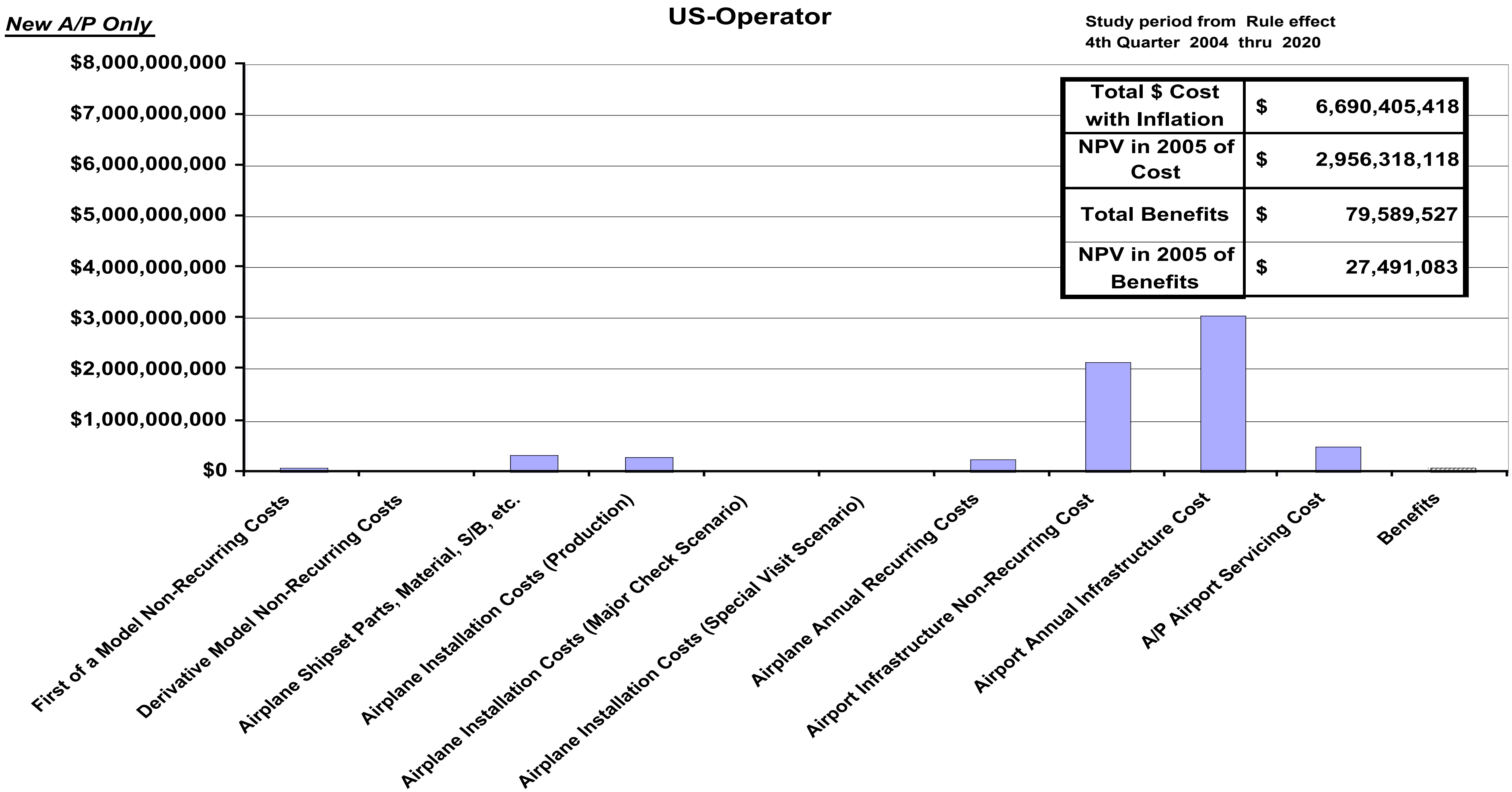
Figure 6

Scenario 11 - Ground Based Inerting HCWT only, All Transports



Total $ Cost with Inflation	$ 6,690,405,418
NPV in 2005 of Cost	$ 2,956,318,118
Total Benefits	$ 79,589,527
NPV in 2005 of Benefits	$ 27,491,083